Viscoelasticity and Shear Thinning near the Critical Point of Xenon

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We describe two measurements of the viscosity of xenon that were made very close (<1 mK) to xenon's critical point (289 K, 5.8 MPa). The first experiment measured the viscosity increase caused by near-critical conditions. It revealed that, close to the critical point, xenon is partly elastic: It can stretch as well as flow. The second experiment, planned for early 2003, will look for the shear-rate-induced viscosity decrease predicted by theory. Such "viscoelasticity" and "shear-thinning" are ordinarily seen only in much more complicated fluids such as polymer solutions. Slowly relaxing fluctuations cause both phenomena. The first experiment found that the time scale for viscoelasticity was 2.0 times slower than predicted. Preliminary results for shear thinning from the second experiment will be reported.

Both experiments were designed to operate in the microgravity provided by the Space Shuttle. We required microgravity because Earth's gravity compresses any fluid near its critical point. Near its critical point, a layer of xenon as thin as 1 mm collapses under its own weight until the density at the bottom is 8% greater than at the top. The density difference distorts the data. Conducting the experiments on the Space Shuttle reduces the density difference by a factor of 100.